Research Proposal of the Thesis Entitled

Investigation of Spatial Visual Ability among Interior Design students

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By

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Introduction

The study of mechanical aptitude and practical ability was where the emergence of the spatial factor initially developed. It is essentially described as the practical ability possessed by an individual which makes him/her adept at determining concrete spatial relations(Mcgee, 1979). During World War II, the Air Force and Army conducted extensive tests of spatial ability, which led to the development of spatial ability as a factor of intelligence. Later studies proved that spatial ability comprises of multiple spatial components. (Tanweer, 2019). Extensive research over the years has led to the emergence of diverse categories within the umbrella of Spatial Skills such as spatial visualization, spatial perception, spatial relations, spatial orientation, and mental rotation. (Kurtulus & Uygan, 2010).

"Spatial visualization is the ability to mentally rotate, manipulate, and twist 2D and 3D stimulus objects." – as stated by Mark G. McGee, Human Spatial Abilities: Psychometric Studies and Environmental, Genetic, Hormonal, and Neurological Influences, September 1979.

The area of research which deals with psychometric constituent of spatial ability focuses on distinguishing multiple space factors within the sphere of Spatial Abilities. Researchers have made attempts to define and list factors comprising spatial ability. The purpose of developmental research is to examine the timeline and stages of development of spatial ability in a child taking into consideration the neurological factors. Among the most explored and researched areas is the section of differential development which addresses the development of spatial ability across gender. Studies indicate that environmental factors and educational factors impact the development of spatial ability. The domain of information processing research and spatial ability attempts to comprehend the processes, speed and order of the cognition. (Tanweer, 2019)

Today, there are substantial studies of Spatial Abilities in the STEM – science, technology, engineering and mathematics fields (Sorby et al., 2018) and likewise in other disciplines like aviation, technical drafting programs, etc (Cho & Suh, 2022). Spatial ability was found to be a significant and statistically independent predictor of pursuing STEM-related courses, graduate school, and other STEM attainment markers. The data presented in the paper by (Sorby et al., 2018) verify that spatial skills intervention has a strong positive impact on STEM performance.

Formulating habitable 3D spaces is an integral component of spatial design within the aegis of interior design and architecture. Castro-Alonso & Atit, 2019 as cited in (Cho & Suh, 2022) mention that visuospatial processing skills are utilised by spatial designers to conceptualize spaces. Spatial visual ability is crucial to ideate spatial design along with imagining the scale of the spaces, the relations with each other and the experiences created for the users of those spaces. These visualization and conceptualization processes require interpretation and translation of 2D and 3D spatial information, collectively recognised as spatial visual ability (SVA) (Cho & Suh, 2022).

Review of Literature

- Mark G. Mcgee (McGee, 1979) established the existence of 2 distinct spatial abilities – spatial visualization and spatial orientation. Visualization and orientation abilities are critical aspects in applied psychology given that they are more highly connected with performance in a number of technical, vocational, and occupational domains than is vocabulary. As a by-product of differences in spatial visualisation and spatial orientation skills, there exist gender inequalities in a variety of perceptual-cognitive functioning domains; and it is not until puberty that gender differences reliably show up on tasks involving spatial visualisation and orientation abilities.
- The meta-analysis conducted by Linn & Petersen (Linn & Petersen, n.d.) established three categories within the domain of spatial ability – (a) spatial perception, (b) mental rotation, and (c) spatial visualization. Furthermore, they suggested – (i) not all types of spatial abilities show gender disparities, (ii) significant gender differences are observed in the assessment of mental rotation, (iii) gender differences are less apparent in the assessment of spatial perception, and (iv) when gender differences are recognized, they can be observed throughout adulthood.
- Peters, M. et all (Peters et al., 1995) in their research "A redrawn Vandenberg and Kuse mental rotations – different versions and factors that affect performance" generated data that indicated significant and replicable gender differences. The original version of the MRT supports previous studies that males perform better than women in these assessments, and moreover, students of physical sciences fare better than those of social sciences and humanities.
- Claudia Quaiser-Pohl (Quaiser-Pohl, 2003) proposed two novel ways to measure spatial aptitude – (i) the "Schnitte" mental cutting test to identify people with exceptional spatial abilities, and (ii) the "Picture Rotation Test" – a mental rotation test for young kids. Both these measures go beyond the restrictions of conventional spatial ability assessments – (a) most

spatial assessments can be resolved analytically and visually, and (b) for preschool children, there is a dearth of standardised assessments available. Numerous studies have also indicated that gender disparities in spatial abilities assessments without time constraints, disappear.

- Sutton and Williams (Sutton & Williams, n.d.-b) in their study, analysed participants' performance on a variety of spatial cognitive tasks that are considered crucial by designers. The 3DAT tasks require a variety of numerous complicated mental processes that reflect a clear understanding of the assigned problem. For a real-life project, with moderate complexities, these tasks represent the kind of understanding that a designer would be expected to have. By comparing results between the unskilled and skilled divisions on both the 3DAT and the paper ability tests, the study evaluated the validity and reliability of 3DAT.
- Following up on the above study, (Sutton & Williams, n.d.-a) conducted a study where the 3DAT – a spatial ability measurement tool, was applied to first year design students and the outcomes were analysed across three parameters – gender, university entrance score and their performance in their first-year academic graphics course. The findings report that females face more struggle compared to males when it comes to solving spatial problems, which lead us to believe that females are more likely to grapple with disciplines that require spatial skills.
- Ömer Akin and Ömer Erem (Akin & Erem, 2011) investigated the significance of learning abstract spatial skills stressed in the earlier years of architectural education, the strength of cognitive-spatial abilities developed by students, by the time they graduate when determining the effectiveness of the architectural curricula. They used an ASAT (Architectural Scholastic Aptitude Test) spatial test to evaluate the undergraduate students of the School of Architecture at Carnegie Mellon University (CMU). The findings indicated that while the students of architecture acquire advance abilities with complex problems, abstract spatial skills developed in the earlier years of architectural curriculum do not maintain at similar levels of competency, much less improve, throughout their undergraduate studies.
- Ji Young Cho (Cho, 2012) conducted an experiment with freshman architecture students at a midwestern university in USA to determine the connections between their spatial abilities, creativity and their academic studio performance. The experiment concluded that students who are skilled at translating 2D information into 3D space and vice versa are more likely to be more creative than those who are not.
- Cohen and Hegarty (Cohen & Hegarty, 2012) discussed the development of the Santa Barbara Solids Test (SBST), a psychometric evaluation of cross-sectioning ability considered as a relevant aspect in many scientific fields. This 30-item multiple choice test, that assesses the individual differences in ability to comprehend the two-dimensional cross section of a three-dimensional geometric solid, was administered online to 223 undergraduate science students.

The study concluded that the SBST is a valid measurement tool that identifies a distinct skill with males considerably outperforming females in majority of the segments.

- Kell et al (Kell et al., 2013) in their study determined that in addition to having a distinct purpose in learning and utilizing formerly acquired knowledge, spatial ability has a unique function in synthesizing creative insight. The psychological framework that supports original thought and innovative activity is limited without spatial ability, and several practical and theoretical endeavours in the psychology sciences are always likely to be inferior.
- Elliot M.'s (Tucker-Drob, 2013) objective was to determine the extents of influence of socioeconomic variations in the demographic in different domains of cognition and competence might be linked to both domain-general and domain-specific developmental pathways. The report concluded that in addition to its association with age-related advancements in general cognitive ability, socioeconomic status was associated to age trends in academic knowledge and mathematical achievement. Also, throughout schooling, age patterns in a variety of various kinds of cognition and competence were found to be related to parental education. The findings imply that socioeconomic disparities have incremental associations with specific types of academic accomplishments even though they primarily emerge in global dimensions of cognitive development.
- Sutton et al (Sutton et al., 2016) discussed the correlation between the spatial ability of the students and their performance in the university entrance assessment – Australian Tertiary Admissions Rank (ATAR). They also examined the consequences of whether or not ATAR is a reliable indicator of spatial abilities of the students. The first-year architecture students at the University of Newcastle were administered the 3-Dimensional Ability Test (3DAT) – an online psychometric assessment tool of spatial ability. No correlation between the ATAR and spatial performance was found based on the results of both the assessments. The study emphasised the need to incorporate initiatives that support the students' spatial skills when entering the university, specifically for design courses.
- Hernández et al (Hernández et al., 2017) in their study analysed the impact of parental educational level, gender and structure of family on the WISC-V full scale Intelligence Quotient (Wechesler Intelligence Scale for Children) and principal scores in a representative sample of Spanish children. The findings confirmed the hypothesis that parental education level is associated with intelligence heritability and surroundings that are intellectually stimulating for children, as parent education level was a strong predictor of the children's FSIQ (full scale intelligence quotient).
- Arslan and Dazkir (Arslan & Dazkir, 2017) explored the possibilities of spatial skill development in initial level students of architecture and the extent to which digital and

physical models enable this process. Determined on the qualitative methods employed to analyse the undergraduate students of Interior Architecture and Environmental Design (IAED) in a Turkish public university, the results indicated that students of interior architecture did not gain any improvement in their ability to visualise interior environments despite taking an engineering based technical drawing course. With additional experience, utilization of physical and digitally generated models, and creative liberty, students begin to comprehend and visualise space with clarity.

- Ji Young Cho in (Cho, 2017) determined the function of creativity, spatial cognition, and visual cognitive styles on students' design studio performance, in relation to gender and academic profile. The participants were administered a number of tests and their final design studio grades were also evaluated that demonstrated that creativity, spatial ability and visual cognitive style cannot be employed to accurately measure and predict performance in design studios. Though there is a favourable relationship between visual cognitive styles and fundamental spatial ability, the males' proficiency in activities requiring general spatial skills and propensity for spatial visualization was revealed.
- Sorby et al. (Sorby et al., 2018) determined whether or not practising spatial abilities improve STEM outcomes in their study. The Revised Purdue Spatial Visualization Test (PSVT: R) was employed as the tool of identification of participating students in the spatial skills remedial course. The results established that some STEM programs had improved scores after enrolment in the remedial course. These remedial courses also enhance the female students' retention chances in engineering and improve their completion scores in multiple key courses.
- Ji Young Cho and Joori Suh (Cho & Suh, 2019) used two sets of spatial ability-measuring tools (1) a general spatial ability test and (2) the Architecture and Interior Design domain-specific Spatial Ability Test (AISAT) – created for this study; to investigate the relationship between the specifics of spatial ability and interior design competence. The findings indicate that while domain-specific spatial ability, which assesses the capacity to translate 2D floor plans into 3D volumetric shapes, is directly connected to interior design performance, general spatial ability is not significantly associated to interior design performance.
- Takeuchi et al. (Takeuchi et al., 2019) scrutinized mean diffusivity's (MD) inherent ability to represent neuronal plasticity and development, the impacts of family socioeconomic status (SES) on MD are still there. Contrary to what was predicted, there were no considerable major symptoms of family SES on MD, independent of gender. Increased family annual revenue was linked, as per psychological assessments, to a variety of psychological measures related to advantages and experiences with characteristics that facilitate positive influences.

Furthermore, higher cognitive performance strongly correlated with parents' higher educational levels with traits associated with beneficial outcomes and experiences.

- González et al. (González Campos et al., 2019) provided empirical evidence confirming the premise that undertaking computer graphics (CG) courses, which are typically offered in computer science or engineering curricula, aid in the improvement of visual-spatial skills. Further investigation from this study indicates that a retest improvement factor even when the exam is retaken twice, and there is a minimal association between students' visual-spatial ability at the start of the course and their cumulative scores at the end of term.
- Charles et al. (Charles et al., n.d.) investigated through variance analysis how the students' spatial visualization abilities can be linked to personal traits and their effects on academic success. The study revealed that MRT had a reduced significant ability to estimate performance on mechanism analysis and that spatial visualization skills had a lower significant capacity to forecast performance on the capability to comprehend codes and construct simple functions in C language. Additionally, an inverse relationship between spatial visualization and effectiveness in applied mathematics was discovered. The study also corroborated the well-documented underperformance of female students in comparison to male students, and those with undergraduate technical histories performed better.
- Ji Young Cho and Joori Suh (Suh & Cho, 2020) probed the relationship between specific characteristics of creative performance in a substantial interior design project and the domain-specific skill of mental rotation and numerous subdimensions of spatial visualization incorporating domain-specific knowledge. The study determined that even those with low spatial ability can create innovative interior design which suggested that even though domain-specific spatial ability and mental rotation are significantly associated with the overall innovativeness of the final outcome, they are nonetheless, a crucial skill connected to the ability to create 3D spatial volumes which is invariably interconnected to the final outcome's creativity.
- Teodora Neagu (Neagu, 2021) established in the study conducted online with 106 participants, males appear to have a stronger spatial orientation skill than females, as evidenced by the fact that men solved most of the questionnaire correctly than women in the STEM group as well as the No-STEM group. The study also observed no variations in the study fields, indicating that all students have the same spatial ability in this instance.
- Ly et al. (Ly et al., 2021) discovered potent evidence for the notion that e-learning programs are fruitful for enhancing spatial abilities, and is specifically productive for students who possess a spatial skills deficit at the time of the initial spatial skills evaluation. It was observed

that females had comparatively weaker spatial skills than males both during the initiation of the program, as well as at its conclusion.

- Gómez-Tone et al. (Gómez-Tone et al., 2021) examined how teaching the freshmen architecture students to sketch architectural spaces in life-size immersive virtual environments affects their spatial skills and scrutinized how previous year's students within the same subject of study perceived visual and spatial information in relation towards how they learned to experience space in virtual, immersive settings. No substantial difference was observed that would allow them to conclude that training including navigation and walkarounds had enhanced spatial orientation and be beneficial to students of architecture who manage places that must be lived in, walked and experienced in. In contrast, the sensation that the designer initially aimed to evoke can be experienced through walkarounds and sensory experimentation in architectural settings that are authentically replicated in immersive virtual reality environments.
- Ji Young Cho and Joori Suh (Cho & Suh, 2022) developed a DSA (domain specific spatial ability) tool – AISAT, that could be utilised to evaluate the spatial ability in interior and architectural design which could connect spatial ability with creative design performance. The split-half correlation and internal consistency findings demonstrated that the AISAT had attained a required degree of reliability. To validate the AISAT, face, content, concurrent, and convergent validity were acquired. The AISAT is most likely to improve (1) researchers who are looking for a reliable instrument to evaluate design students' spatial abilities, (2) tutors who want to examine the effects of their involvement in students' spatial design performance in connection to their spatial abilities, and (3) scholars that are interested in spatial design and are looking to go beyond the conventional psychometric method.

Problem Statement

Few studies have investigated the Spatial Visual Ability and demographic factors of Interior Design students. Till date, no studies have been conducted in the Indian context. Currently, there are approximately 5,000 students in design schools and universities. The ignorance (of the effects) of demographic factors during the design of the course modules might affect the development of the design students' Spatial Visual Ability.

Aim

To investigate the association between Spatial Visual Ability (SVA) across interior design students (from beginner to advanced years) and demographic factors.

Objectives

1. To study the effects of age, educational background and gender on the Spatial Visual Ability among interior design students in India.
2. To identify the aspects of Spatial Visual Ability on which the influence of age and gender in the interior design students in India is found.
3. To determine the correlation between socioeconomic status and the Spatial Visual Ability of interior design students in India.
4. To frame a proposal for upgrading spatial skills training among interior design students in India.

Rationale

Understanding the correlation between the demographic factors on the Spatial Visual Ability (SVA) of the interior design students shall help in developing effective training programs / strategies as part of academic instruction to improve their Spatial Visual Ability.

A fact – corroborated by Schoenfeld et al. (Schoenfeld et al., 2010) which states that understanding the effect of age and gender helps to develop a better learning environment for students.

Motivation

Spatial Design, which is practiced in architecture and interior design, aims at designing environments 'to support intended activities and to enrich human experiences' by using a variety of spatial components.

Identifying the external factors that influence the Spatial Visual Ability (SVA) of interior design students becomes imperative to understand the sub-constructs of spatial abilities.

Research Questions

1. What is the effect of the demographics on the Spatial Visual Ability of interior design students in India?
2. What is the effect of the academic training on the Spatial Visual Ability of interior design students in India?
3. What is the association between Spatial Visual Ability and demographics of the interior design students in India?
4. What could be the framework for upgrading spatial skills training among interior design students in India?

Hypothesis

H0 – Null Hypothesis

There is no significant association between Spatial Visual Ability (SVA) and demographic factors of the Indian interior design students.

Ha – Alternative Hypothesis

There is a significant association between Spatial Visual Ability (SVA) and demographic factors on Indian interior design students.

Methodology

1. Literature Review
   - Problem statement
   - Literature review
   - Research gap
   - Aim & Objectives

2. Research Design
   - Conduct survey based on appropriate sampling techniques
   - Independent & Dependent variables to conduct survey

3. Data Collection
   - Factors / Parameters measured:
   - Mental Rotation
   - Spatial Visualization 1A, 1 & 2
   - Time using stop-start watch

4. Analysis of Results

- Multiple Regression analysis
- MANOVA & ANOVA
- T-test statistical analysis

5. Hypothesis testing
   - Strategy for upgradation of Spatial Visual Ability - SVA

6. Final Documentation

Expected Outcomes

1. Gain a database of the Spatial Visual Ability (SVA) of interior design students in India.
2. Create a set of guidelines for other design disciplines by adopting the same methodology.
3. Develop analytical and holistic strategies to upgrade the Spatial Visual Ability of interior design students in India.

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